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The lichen genus *Kroswia* in China

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Abstract —Three species belonging to the lichen genus *Kroswia* are reported from China: *Kroswia epispora* sp. nov., *K. crystallifera*, and *K. gemmascens*. The colourless ellipsoid ascospores with epispore in *K. epispora* provide new evidence for the close relationship between *Kroswia* and *Fuscopannaria*. Descriptions and comments for the three species and a key to all *Kroswia* species are presented.

Key words —*Ascomycota*, *Pannariaceae, Peltigerales,* taxonomy

Introduction

Kroswia P.M. Jørg. is a small, paleotropical genus belonging to *Pannariaceae*, *Peltigerales*, *Lecanoromycetidae*, *Ascomycota.* It differs from other genera in the family by its gelatinous, homoiomerous, and ecorticate thallus and the presence of terpenoids and fatty acids (Jørgensen 2002, 2003a). The genus contains three species: *Kroswia crystallifera* (the type), *K. gemmascens*, and *K. polydactyla* (Jørgensen 2002, 2003a, 2004; Jørgensen & Gjerde 2012).

Only *K. gemmascens* is known to be fertile, and its hymenium characters suggest a close relationship with *Fuscopannaria* P.M. Jørg. (Jørgensen 2007). This was further confirmed by a recent molecular study suggesting that *K. cystallifera*, the type of the genus, should be included in *Fuscopannaria* (Magain & Sérusiaux 2014), making the genus *Kroswia* a later synonym of *Fuscopannaria* (Magain & Sérusiaux 2015). However, another recent molecular phylogeny of *Pannariaceae* failed to obtain PCR products from *Kroswia* samples, and the authors therefore retained *Kroswia* as a separate genus (Ekman et al. 2014). Because the placement of the other two *Kroswia* species in *Fuscopannaria* lacks molecular support, we follow here the traditional concept of *Kroswia*.

Two *Kroswia* species have been reported from China, *K. crystallifera* from Taiwan (Jørgensen 2002) and *K. gemmascens* from mainland China (Zahlbruckner 1930; Wei 1991; Jørgensen 2002, 2007). Here we describe *Kroswia epispora*, and present a key to all *Kroswia* species.

Materials & methods

Specimens are deposited in Herbarium Mycologicum Academiae Sinicae-Lichenes, Beijing, China (HMAS-L), the Herbarium of Kunming Institute of Botany, Chinese Academy of Sciences, Kunming, China (KUN), the Herbarium of Nanjing Normal University, Nanjing, China (NJNU), and the Herbarium of Shandong Normal University, Jinan, China (SDNU). Dissecting microscopes (Motic SMZ-140 and Olympus SZ51) and light microscopes (Motic B2 and Olympus CX21) were used for the morphological and anatomical studies. Photographs were taken with BX51 fluorescence microscope.

Color tests and thin-layer chromatography (TLC) were routinely performed as described by Culberson & Kristinsson (1970), Culberson (1972), Culberson et al. (1977), Huneck & Yoshimura (1996), and Orange (2010). The K, C, and P reagents were used for color tests. The solvent system C for TLC was used to develop acetone extraction of the thallus fragments on a silica gel-coated glass plates. Lugol's solution was added to the apothecial sections for Iodine reaction.

Taxonomy

Kroswia epispora H.J. Liu & Chao Li, **sp. nov.** Pl. 1

MycoBank MB 811551

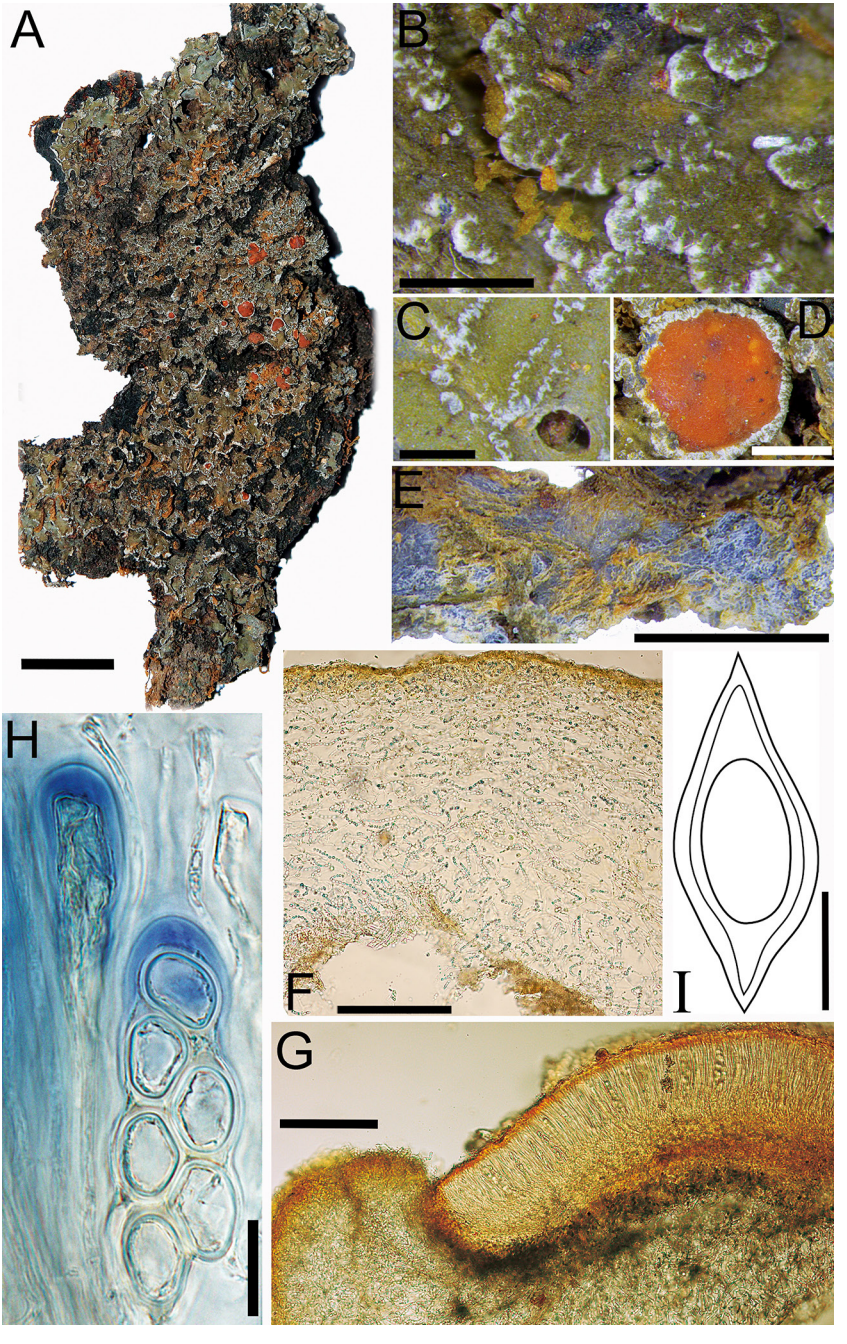
Differs from *Kroswia crystallifera* by the presence of apothecia and absence of gymnidia.

Type: China. Zhejiang Province, Mt. Jiulongshan, 28°22 N 118°52 E, alt. 1600 m, on bark, 8/V/1987, Shu-Fan Chen Z0923 (**Holotype**, NJNU).

Etymology: The epithet refers to the epispore of the ascospores.

Thallus foliose, orbicular to irregular spreading, 4–9 cm in diam., partially fenestrate, without distinct hypothallus; lobus rounded, up to 4–5 mm broad; upper surface olivaceous brown, glabrous, uneven to irregularly warted, sparsely wrinkled (warts and part of wrinkles sometimes bearing white powder crystals), without gymnidia, marginally with white marbling and bearing white terpenoid crystals; lower surface bluish gray near margin, blackened towards center, smooth to finely wrinkled, with scattered tufts of rhizines. Apothecia

Plate 1. ***Kroswia epispora*** (holotype, NJNU Chen, Z0923). A. Thallus with apothecia; B. Upper surface, showing lobe margins with white terpenoid crystals; C. Upper surface, showing fenestrated thallus and sparse wrinkles with white powder crystals; D. An apothecium, showing thalline margin with white powder crystals; E. Lower surface; F. Cross-section of thallus; G. Cross-section of apothecium, showing the ecorticate and well-developed apothecial margin; H. Ascus and ascospores, showing the amyloid ring structure of ascus apex, and subglobose ascospores in ascus; I. Ascospores, showing distinct, smooth epispore. Scale bars: A= 1 cm; B, C = 0.4 mm; D = 1 mm; E = 5 mm; F, G = 150 μm; H = 20 μm; I = 10 μm.


A
B
C
D
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I

common, laminal, mainly adnate upon the center of the thallus, 2–3 mm in diam.; DISC plane to convex, reddish brown; THALLINE EXCIPLE thick, glabrous, smooth to warted, crenate at margins, beset with white powder crystals.

THALLUS homoiomerous, 300–400 μm thick, ≤500 μm thick when wet; BOTH CORTICES lacking, brown at the uppermost 20 μm and lowermost 10 μm portions, colourless or somewhat bluish at the rest portions; PHOTOBIONT *Nostoc* in long chains, consisting of more than 10 cells of 4–5 μm in diam.; HYPHAE regularly interwoven.

APOTHECIA lecanorine; THALLINE EXCIPLE well-developed, 350–450 μm thick at the margin, without cortex, with an algal layer of long chains of *Nostoc* and radiating hyphae; PROPER EXCIPLE poorly-developed or lacking; HYMENIUM 100–140 μm high, hemiamyloid (I+ blue, rapidly turning red-brown), with a thin, pale yellow-brown epithecium; PARAPHYSES simple, 1.5–3 μm thick, slightly thickened at the apices; SUBHYMENIUM well-developed, ≤100 μm high, of non-oriented, closely compacted hyphae; ASCI cylindrical-clavate, apically with an internal amyloid ring structure, 8-spored; ASCOSPORES colourless, subglobose to broadly ellipsoid in asci, ellipsoid when released, tapered at both ends, with visible, smooth epispore, 25–32 × 10–12 μm.

Corticolous.

CHEMISTRY: All reactions negative (color test); terpenoids and fatty acids present (TLC).

ADDITIONAL SPECIMENS EXAMINED: **CHINA. SICHUAN PROVINCE**, Mt. Emeishan, on bark, alt. 3160 m, 17/VIII/1963, J.D. Zhao & L.W. Xu 07659 (HMAS-L 036844), 7773-1 (HMAS-L 131145); alt. 3100 m, on bark, 14/XI/1964, J.C. Wei 2252-1 (HMAS-L 131144), 2903-1 (HMAS-L 105161).

REMARKS: The new species is corticolous in montane forests from Sichuan and Zhejiang Provinces of China. It is characterized by a homoiomerous thallus without cortices, white marbled lobe margins, ellipsoid colourless ascospores with an epispore, absence of gymnidia, and presence of terpenoids and fatty acids.

Kroswia gemmascens is also fertile, but has gymnidia and light brown ascospores without epispore; its globose, brown-pigmented ascospores are unique in *Pannariaceae* and an important character distinguishing *Kroswia* from *Fuscopannaria* (Jørgensen 2007, Ekman et al. 2014). The ellipsoid colourless ascospores in *K. epispora* are similar to those in *Fuscopannaria*, providing new evidence for the close relationship between the two genera.

Kroswia polydactyla P.M. Jørg. also lacks gymnidia on the thallus, but it has dactyliform lobes and has no lichen substances detectable by TLC. The new species may be a fertile counterpart of *K. crystallifera*. Both species are morphologically very similar, but *K. crystallifera* is sterile with abundant gymnidia.

Kroswia crystallifera P.M. Jørg., Lichenologist 34(4): 299 (2002). Pl. 2 A–C
≡ *Fuscopannaria crystallifera* (P.M. Jørg.) Magain & Sérus., Lichenologist 47(1): 39 (2015).

Thallus foliose, membranaceous, irregular spreading, 3–9 cm in diam., partly fenestrate, without distinct hypothallus; lobus flattened, flabellate, up to 3 mm broad; upper surface olivaceous grey to olivaceous brown, glabrous, sparsely wrinkled, with sparse to dense, white marbling, marginally beset with bluish grey gymnidia (sometimes also spreading to upper surface); gymnidia always covered with white terpenoid crystals; lower surface bluish gray near margin, blackened towards center, distinctly veined, with scattered tufts of blackish rhizines.

Thallus homoiomerous, ≤500 µm thick when wet, brown near both sides, the rest portions colourless; both cortices lacking; photobiont *Nostoc* in chains, small-celled, 4–6 um in diam.; hyphae loosely interwoven.

Apothecia not seen.

On bark, rarely on moss covered rocks.

Chemistry: All reactions negative (color test); terpenoids present (TLC).

Specimens examined: **China**. **Anhui Province**, Mt. Huangshan, on bark, alt. 1330 m, 09/VIII/1978, Z.G. Qian, 01484a (NJNU); alt. 1000 m, 09/IX/1981, Z.G. Qian 03203 (NJNU). **Guizhou Province**, Mt. Fanjingshan, on shrubs, alt. 2100 m, 04–05/VII/1988, L.S. Wang 88-187, 88-192, 88-248 (KUN). **Hubei Province**, Shennongjia, on bark, alt. 2650 m, 20–30/VII/1984, A.T. Liu 8401312, 8401430, 8401510 (NJNU); alt. 1350 m, 09–10/VIII/1984, J.N. Wu 8401821, 8401867 (NJNU). **Sichuan Province**, Yanyuan County, on bark, alt. 3450 m, 26/VII/1983, L.S. Wang 83-1339 (KUN); alt. 3100 m, 11/VIII/1983, L.S. Wang 83-1509 (KUN); Luding County, Mt. Gonggashan, on rotten branches, alt. 2800 m, 01/IX/1996, L.S. Wang 96-16287 (KUN). **Zhejiang Province**, Mt. Jiulongshan, on bark, alt. 980–1450 m, 4–8/V/1987, S.F. Chen Z1334, Z1348, Z0544 (NJNU); 29/IV/1987, S.F. Chen Z0792, Z0796 (NJNU); Mt. Tiantaishan, on bark, alt. 730 m, 24/VIII/1986, Z.G. Qian, 04514 (NJNU).

Remarks: The species is characterized by a glabrous sparsely wrinkled and white marbled upper surface, lobe margins with gymnidia, a veined lower surface, a homoiomerous thallus without cortices, and the presence of terpenoids. It has been reported from Australia, East Africa, Madagascar, Reunion, South Asia, and Taiwan of China (Jørgensen 2002, 2003a, b, 2004; Magain & Sérusiaux 2014). The new materials reported here were collected on barks in subtropical montane forests and extend the Chinese range from Taiwan westward to southern Sichuan.

Kroswia crystallifera is the type of the genus (Jørgensen 2002), and has been suggested to belong to *Fuscopannaria* (Magain & Sérusiaux 2014, 2015), from which it differs, however, by the homoiomerous thallus without proper cortices. It differs from *K. gemmascens* in the white marbled upper surface (especially noticeable near the margins), less wrinkled lobes, a fenestrate foliose thallus,

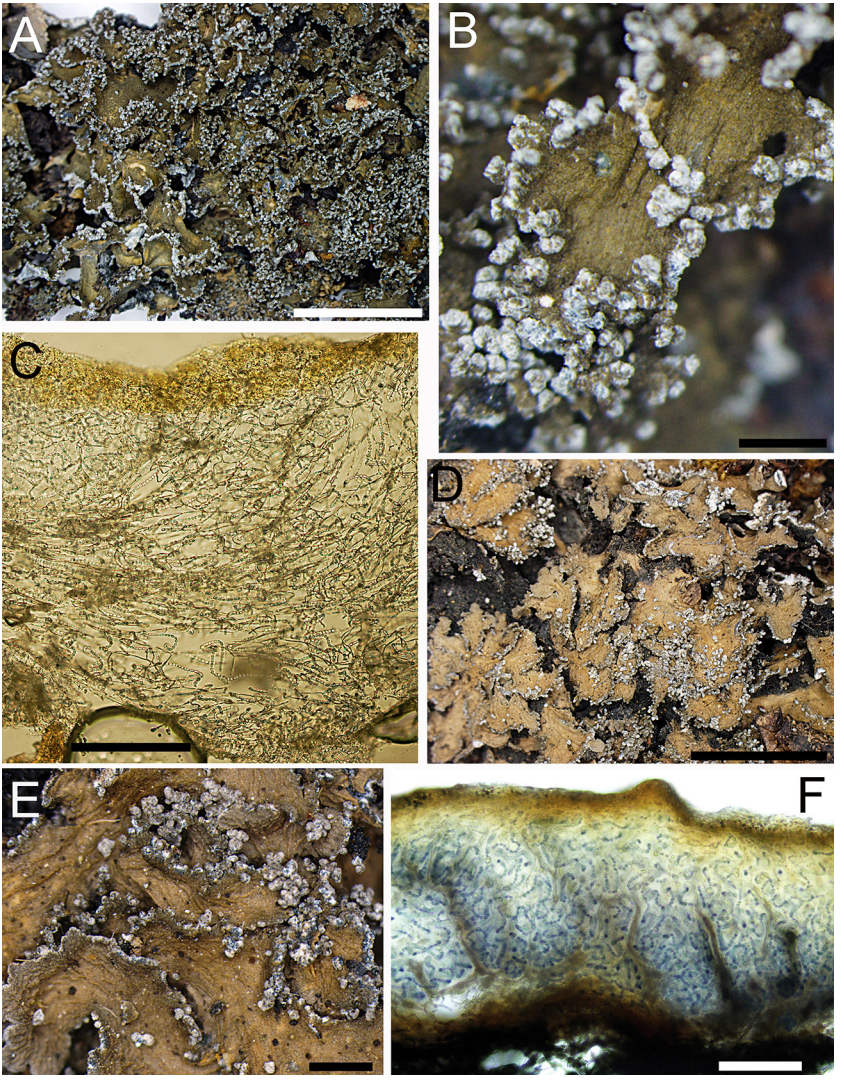

Plate 2. ***Kroswia crystallifera*** (NJNU Liu 8401430). A. Thallus; B. Lobes, showing slightly wrinkled upper surface and gymnidiate lobe margins; C. Cross-section of thallus. ***Kroswia gemmascens*** (HMAS-L 073208). D. Thallus; E. Lobes, showing wrinkled upper surface and gymnidiate margins; F. Cross-section of thallus. Scale bars: A, D = 1 cm; B, E= 0.5 mm; C, F = 100 μm.

and the absence of apothecia. *Kroswia epispora* and *K. polydactyla* differ by the absence of gymnidia.

Wu & Qian (1989) reported *Physma gemmascens* and *P. pergranulatum* (both synonyms of *K. gemmascens*) from eastern China without citing any specimens, but most of the specimens in NJNU that they identified by these names represent *K. crystallifera*.

Kroswia gemmascens (Nyl.) P.M. Jørg., Lichenologist 34(4): 302 (2002). Pl. 2D–F

≡ *Pannaria gemmascens* Nyl., Lich. Japon.: 36 (1890).

≡ *Physma gemmascens* (Nyl.) Asahina, Journ. Jap. Bot. 38: 66 (1963).

= *Physma pergranulatum* Zahlbr., Symb. Sin. 3: 75 (1930).

Thallus squamulose, ≤1.5 cm diam., forming rounded to irregular rosettes ≤3–7 cm diam., without distinct hypothallus; lobes rounded to somewhat elongated, auriform, 1–2 mm wide; upper surface light brown to dark brown, without white marbling, often wrinkled when dry, gelatinous and considerably swelling when wet; gymnidia marginal, rarely also spreading to upper surface, granular, bluish-white, often covered with white terpenoid crystals; lower surface marginally light brown to whitish, darker towards the center, partly with bluish-black rhizohyphae in the center.

Thallus homoiomerous, ≤400 μm when wet; both cortices lacking; photobiont *Nostoc* in chains.

Apothecia not seen.

On barks and mosses.

Chemistry: All reactions negative (color test); terpenoids and fatty acids present (TLC).

Specimens examined: **China**. **Anhui Province**, Mt. Huangshan, on bark, alt. 1610 m, 20/VIII/1962, J.D. Zhao & L.W. Xu 5532 (HMAS-L 073208). **Guizhou Province**, Kaili City, Mt. Leigongshan, on bark, alt. 1800 m, 23/VIII/2010, D.F. Jiang 20102857 (SDNU); Daozhen County, Dashahe, on bark, alt. 1500 m, 10/VI/1987, X.L. Wu 2960 (HMAS-L 073223). **Hunan Province**, Guidong County, Sidu Town, on mosses, 17/VIII/2000, M.R. Huang 005 (HMAS-L 036431). **Jiangxi Province**, Mt. Lushan, on mosses, alt. 1150 m, 11/II/1965, J.C. Wei 3129 (HMAS-L 036429).

Remarks: The species is characterized by a squamulose non-fenestrate thallus, auriform lobes, a wrinkled and non-marbled upper surface, marginal gymnidia, and a homoiomerous non-corticate thallus. It is a fertile species with globose brown spores (Jørgensen 2007), but our materials are all sterile.

The species has been recorded from Japan and China [Sichuan, Xizang, and the Jiangxi/Fujian border] (Jørgensen 2002, 2003a, 2007; Zahlbruckner 1930, as *Physma pergranulatum*). The new materials reported here were collected on barks or mosses from montane forests and extend the Chinese range to Anhui, Guizhou, Hunan, and Jiangxi Provinces.

Wu & Qian (1989) reported this species (without citing any specimens) from Anhui, Fujian, and Jiangxi (as *Physma pergranulatum*) and from Zhejiang

and Hubei (as *P. gemmascens*), but most of the specimens at NJNU that they identified by these names represent *Kroswia crystallifera*. Both *K. gemmascens* and *K. crystallifera* are gymnidiate species; for a comparison see the remarks under *K. crystallifera*, above.

Key to species of *Kroswia*

1 Gymnidia present 2
Gymnidia absent 3

2 Thallus foliose; lobes flabellate; upper surface sparsely wrinkled; apothecia and ascospores unknown ..... *K. crystallifera*
Thallus squamulose; lobes auriform; upper surface densely wrinkled; ascospores globose, pale brown, without a distinct epispore ..... *K. gemmascens*

3 Lobes dactyliform; terpenoids absent; apothecia unknown ..... *K. polydactyla*
Lobes flabellate; terpenoids present; ascospores ellipsoid, colourless, with a distinct epispore ..... *K. epispora*

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